Comparison Between Experimental Data and Model Calculations of Excitation Functions for Production of Radionuclides for Metabolic Radiotherapy and PET

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The radioisotope production for medical applications has been brought up in the years at INFN LASA Laboratory. Mainly scientific aspects applications have been investigated concerning radiation detection and relevant instruments, the measurements of excitation functions of the involved nuclear reactions and the requested radiochemistry studies. Concerning the related nuclear data evaluations, based on model calculations and critically selected experimental data, the appropriate competence developed at ENEA Division for Advanced Physics Technologies has been implemented in this work. The EMPIRE-II code is adopted following an inter-comparison with previous ENEA codes.

A series of high specific activity accelerator-produced radionuclides in no-carrier-added (NCA) form, for uses in metabolic radiotherapy and for PET, are investigated, such as:
1. NCA ^{64}Cu, produced by ^{nat}Zn(d,axn) and ^{nat}Zn(d,2pxn) reactions for simultaneous positron/negatron metabolic radiotherapy and PET, together with the short-lived radionuclide for PET imaging ^{61}Cu;
2. NCA ^{66}Ga, high-energy positron emitter (4.2 MeV) for metabolic radiotherapy and PET;
3. ^{186g}Re, produced by ^{186}W(p,n) and ^{186}W(d,2n) reactions for bone metastases pain palliation by negatron(1.1 MeV) metabolic radiotherapy and SPECT imaging;
4. NCA ^{211}At/^{211}Po, produced by ^{209}Bi(α,2n) reaction, with internal spike of gamma emitter ^{210}At from ^{209}Bi(α,3n) reaction (and small amount of ^{210}Po as radiotoxic long-lived impurity), for high-LET radiotherapy and immunoradiotherapy;
5. NCA ^{225}Ac/^{213}Bi/^{213}Po, in-vivo nano-generator for high-LET radiotherapy and immunoradiotherapy.

In this work, new revised measurements and model calculations are presented for excitation functions of ^{nat}Zn(d,X)^{61,64}Cu,^{66}Ga reactions, referring to irradiation experiments at K=38 Cyclotron at JRC-Ispra. Concerning the reaction data for producing ^{186g}Re and ^{211}At/^{211}Po (including significant emission spectra) and ^{210}At, the most recent and critically selected experimental results are discussed, in comparison with model calculations paying special care to pre-equilibrium effects estimate and to appropriate overall parameterisation. Only model calculations are presented for ^{226}Ra(p,2n)^{225}Ac reaction, in lack of extremely difficult measurements.

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